PATENT COOPERATION TREATY
PCT
INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

REC'D 28 NOV 2005
WIPO PCT

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 12527670/DH/gjm	**FOR FURTHER ACTION**	See Form PCT/IPEA/416
International application No. **PCT/AU2004/001004**	International filing date *(day/month/year)* 29 July 2004	Priority date *(day/month/year)* 19 January 2004

International Patent Classification (IPC) or national classification and IPC

Int. Cl. [7] B32B 3/10, 3/12, 3/20, 3/24, 3/26, 3/28, 3/30, 5/26, 5/28, 15/02, 15/14; F41H 1/02, 5/04

Applicant

MUSAEFENDIC, Jasko et al

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 3 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. [X] *(sent to the applicant and to the International Bureau)* a total of **19** sheets, as follows:
      - [X] sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      - [ ] sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.

   b. [ ] *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or table related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).
4. This report contains indications relating to the following items:

[X]	Box No. I	Basis of the report
[ ]	Box No. II	Priority
[ ]	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
[ ]	Box No. IV	Lack of unity of invention
[X]	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
[ ]	Box No. VI	Certain documents cited
[ ]	Box No. VII	Certain defects in the international application
[ ]	Box No. VIII	Certain observations on the international application

Date of submission of the demand 29 July 2004	Date of completion of the report 22 November 2005
Name and mailing address of the IPEA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized Officer **A Davies** Telephone No. (02) 6283 2072

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY	International application No. **PCT/AU2004/001004**

Box No. I **Basis of the report**

1. With regard to the **language,** this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.

   ☐ This report is based on translations from the original language into the following language , which is the language of a translation furnished for the purposes of:

   ☐ international search (under Rules 12.3 and 23.1 (b))

   ☐ publication of the international application (under Rule 12.4)

   ☐ international preliminary examination (under Rules 55.2 and/or 55.3)

2. With regard to the **elements** of the international application, this report is based on (*replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report*):

   ☐ the international application as originally filed/furnished

   ☒ the description:

   pages as originally filed/furnished

   pages* **1-10** received by this Authority on **17 June 2005** with the letter of **16 June 2005**

   pages* received by this Authority on with the letter of

   ☒ the claims:

   pages as originally filed/furnished

   pages* as amended (together with any statement) under Article 19

   pages* **11-17** received by this Authority on **17 June 2005** with the letter of **16 June 2005**

   pages* received by this Authority on with the letter of

   ☒ the drawings:

   pages **1-3** as originally filed/furnished

   pages* received by this Authority on with the letter of

   pages* received by this Authority on with the letter of

   ☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing.

3. ☐ The amendments have resulted in the cancellation of:

   ☐ the description, pages

   ☐ the claims, Nos.

   ☐ the drawings, sheets/figs

   ☐ the sequence listing (*specify*):

   ☐ any table(s) related to the sequence listing (*specify*):

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).

   ☐ the description, pages

   ☐ the claims, Nos.

   ☐ the drawings, sheets/figs

   ☐ the sequence listing (*specify*):

   ☐ any table(s) related to the sequence listing (*specify*):

* *If item 4 applies, some or all of those sheets may be marked "superseded."*

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/AU2004/001004

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims **1-60**	**YES**
	Claims	**NO**
Inventive step (IS)	Claims **1-60**	**YES**
	Claims	**NO**
Industrial applicability (IA)	Claims **1-60**	**YES**
	Claims	**NO**

2. Citations and explanations (Rule 70.7)

DE 10153165 A1 (Wellnitz J.), 8 May 2003 & Derwent Abstract Accession No. 2003-450513/43, Class F04

"Static Properties of Fibre Metal Laminates", Hagenbeek M. et. Al., Applied Composite Materials Vol. 10, no 4- 5, pp 207- 222, July 2003. ISSN 0929-189X
Ingenta Online Abstract

US 2003/0180517 A1 (Karall), 25 September 2003

US 5903920 A (Granqvist), 18 May 1999

US 6063716 A (Granqvist), 16 May 2000

Novelty (N) and Inventive Step (IS)

None of the documents either individually or in obvious combination disclose all of the features of the claims. In particular there is no disclosure of a laminated product having outer layers, intermediate plies and a dissipating element, wherein the dissipating element redirects a load applied to an outer layer to tensile loading of the intermediate plies. Consequently claim 1- 60 are novel and involve an inventive step.

PCT/AU2004/001004
Received 17 June 2005

HIGH STRENGTH, IMPACT RESISTANT, ELASTIC COMPOSITE LAMINATES

Field of the Invention

The present invention relates to high impact resistant composite laminate structures.

Background of the Invention

It is known to utilise physical characteristics of fibre composites to enhance impact resistant properties of, for example, a laminate structure. However, the elastic properties of continuous and unidirectional fibrous composites are highly anisotropic and depend of fibre orientation with respect to the applied stress. The axial tensile strength of a unidirectional lamina is typically controlled by the fibre ultimate strain. The transversal tensile strength of a unidirectional lamina is mainly controlled by the matrix ultimate strain. The strength of a fibre reinforced structure is at least an order of magnitude greater in the longitudinal direction than in the transversal/perpendicular direction to the fibre main axis.

Object of the Invention

The present invention seeks to provide a new laminate which utilises a composite structure.

Summary of the Invention

In accordance with the invention, there is provided a high-strength, impact resistant, elastic, fibre composite laminate including at least two inner fibre plies and at least one dissipating element between the inner plies, wherein said at least one dissipating element dissipates and redirects a load applied to the laminate to tensile loading of at least one of said inner plies directed along its longitudinal axis.

In another aspect, there is provided a nanostructure including at least two inner fibre plies and at least one dissipating element between the inner plies, wherein said at least

PCT/AU2004/001004
Received 17 June 2005

one dissipating element dissipates and redirects a load applied to the laminate to tensile loading of at least one of said inner plies directed along its longitudinal axis.

Preferably, the laminate includes a pair of outer layers and a polymer matrix between each of the plies and the outer layers.

In comparison with known structural materials the laminate offers a unique combination of mechanical strength, especially during extreme dynamic loading (impact), with significant weight reduction in comparison with similar samples made from steel or aluminium.

Brief Description of the Drawings

The invention is described by way of non-limiting example only, with reference to the drawings, in which:

Figure 1 is a fragmentary cross-sectional view of a laminate with tubes as dissipating elements.
Figure 2 is a fragmentary cross-sectional view of a laminate with corrugated sheet as dissipating elements.
Figure 3 is a fragmentary cross-sectional view of a laminate with ornamesh/rigidised form as dissipating elements.
Figure 4 is a graph showing the relationship between samples weight and respective impact energy absorbed.
Figure 5 is a graph showing weight comparison between samples.

Detailed Description of a Preferred Embodiment

A laminate structure formed in accordance with the invention represents a new approach in damage tolerant material design philosophy with optional first and second outer face layer for forming an outer face (4), at least two inner plies (2), a dissipating element (1) and usually (dominantly) polymer matrix (3).

PCT/AU2004/001004
Received 17 June 2005

The dissipating elements may be various metal, non-metal, natural and non-natural structures in a form of, but not limited to: expanded metal, ornamesh, rigidised metal, corrugated sheet, tubular shape, spherical shape, other geometric shapes, ribbed, textured, woven mesh (plain, twill square, holander, micron), and any other similar geometric forms, or other structures having the function of dissipation and redirection of local active outer loading (perpendircular/transversal or impact) applied to at least one of the faces, to tensile loading, of at least one of said inner reinforced plies directed along its longitudinal axis.

The outer plies (2) are constructed from a variety of dry or pre-impregnated (prepregs) reinforcement materials such as but not limited to: Glass, Aramid, Carbon, Quartz, Borron, Basalt, Polyurethane, natural, non-natural, and any other single or hybrid fibres, in combination with variety of any known thermosetting and thermoplastic matrixes (3) such, but not limited to: Vinylester, Epoxy, Phenolic, Polypropylene Nylon, Polyester, Amino, Bismaleimides, Polyether, Silicones, Cyanatesters, Polybutadhine, Polyetheramide, Polyimides, fire retardant, corrosion resistant, any sort of adhesives, coatings, pigments, sealants, catalysts, accelerators, diluents, etc.

The optional outer face layers (4) may be made from a variety of any metallic, non-metallic natural or non-natural materials.

The above described laminate structure represents a singular variation of material creation, and there is possibility to apply plurality of plies as described above in any possible direction and combination.

Figure 1 illustrates basic principles of internal force-impact energy dissipation and redirection of local active loading (impact) [F] applied to at least one of the two outer faces of the new structure, to longitudinal (tensile) reaction [Fi] in fibre reinforcement plies in a single structure. These forces are forming force equilibrium as shown on Figure 1 show an example of the laminate structure (7) where the Aluminium tubes (1) are used as dissipating elements.

PCT/AU2004/001004
Received 17 June 2005

Figures 2 and 3 show another two examples (single structure) where applied various metal structures (expanded metal, ornamesh, rigidised forms, corrugated sheets), as the dissipated elements (1), can redirect outer active force/impact energy [F] to the face of the structure, to the tensile force/reaction [Fi] in the longitudinal axis of reinforcement plies (2).

Figure 3 show very high consistency of impact energy absorbed by Strength, Impact Resistant, Elastic Composite Laminate samples.

Figure 4 show significant specific weight reduction of Novel High Strength, Impact Resistant, Elastic Composite Laminate materials in comparison with steel and aluminium.

To further expand on the above, to achieve internal active force/impact energy dissipation and redirection in the laminate (Figure 1) various metallic and non-metallic structures may be used as dissipating elements including but not limited to: expanded metal, ornamesh, rigidised forms, corrugated sheets, tubular shapes, spherical shapes, weave mesh (plain, twill, square, Hollander, micron) metallic or non-metallic foams, foam like structures and any other similar forms (2), and include but are not limited to one or more elements selected from the following metallic, non-metallic, natural and non-natural material groups including but not limited to: aluminium alloys, steel alloys, zinc alloys, titanium alloys, copper alloys, magnesium alloys, nickel alloys, brass alloys, carpenter, gold, silver, platinum, hastelloy, haynes alloy, inconel, molybden alloy, palladium, bronze, tantalum, monel, tungsten, borron, beryllium, zintec, matrix composites, thermoplastics, thermosets, plastics, foams, wood, rubber, paper, ceramics, leather, balsa, cedar, liquids and gases (vacuum) as a single components or compositions.

As a result of loading redirection/dissipation, there are now tensile-reactive forces/loadings in at least one of reinforcement plies directed along its longitudinal axes and, based on mechanical properties of fibre reinforcement materials where the tensile strength of reinforcement materials is at least an order of magnitude higher than transversal strength, the result is the significantly higher strength, especially

PCT/AU2004/001004
Received 17 June 2005

impact resistant, novel laminate structure.[MC1] In comparison with already known/existing composite structures whose major disadvantage is brittleness, the laminate can offer high impact resistance with exceptionally high levels of elastic/plastic deformability and high percentage of elastic recovery after plastic deformation.

With application of this invention, the impact resistance of the laminate does not depend mainly on the matrix's (3) properties; it is now mainly dependable on the fibre reinforcement's mechanical properties.

Specific, desirable properties of new composite structures include:

- redirection and dissipation of outer transversal/perpendicular loading/impact to tensile loading along longitudinal axis in reinforcement inner plies,
- high impact strength,
- high energy-absorbing ability,
- high elastic/plastic deformability under impact,
- high percentage of elastic recovery during plastic deformation,
- low density,
- high tensile strength in all directions,
- high fatigue resistance and durability,
- simple and cost-effective machining and fabricating.

Production of a suitable laminate can include all known processes in composite manufacturing such as, but not limited to: hand lay-up, wet lay-up, spray-up, bag moulding, pressure/vacuum bag moulding, match moulding, press moulding, infusion, open moulding, closed moulding, sequentical moulding, continuous moulding, resin transfer moulding, autoclave moulding.

The laminate structure is made from cost-effective and standard materials readily available and exhibits significant proven improved mechanical properties in comparison with all existing composite laminates.

PCT/AU2004/001004
Received 17 June 2005

With respect to orientation, these internal dissipating elements may be arranged as, but not limited to, unidirectional, cross-ply, symmetric, balanced and quasi-isotropic.

As components in the manufacturing of a diverse variety of laminates it is possible to use any known single or hybrid dry or preimpregnated (prepregs) reinforcement fibres that are made from one or more materials selected from the groups consisting of, but not limited to: Glass (E, S, S-2, T, E-CR), Aramid, Carbon/Graphite, Quartz, Ceramic, PBO, Basalt, Boron, Polyethylene, Natural and hybrid fibre reinforcements (2) as, but not limited to: Quadriaxial, Unidirectional, Double-bias, Biaxial, Triaxial, Plain woven, Woven rovings, Braided, Yarn, 3 Weave rovings, Chopped strands, Mats, simultaneous stitches with use of any known matrixes (3) but not limited to: Vinylester, Epoxy, Phenolic, Polypropylene Nylon, Polyester, Amino, Bismaleimides, Polyether, Silicones, Cyanatesters, Polybutadhine, Polyetheramide, Polyimides, fire retardant, corrosion resistant, any sort of adhesives, coatings, pigments, sealants, catalysts, accelerators, diluents, etc.

With respect to orientation, reinforcement plies may be arranged in a number of ways, including: unidirectional, cross-ply, symmetric, balanced, quasi-isotropic and hybrid laminates.

Optional outer face layers (4), whether for protective or decorative purpose, may be one of the metallic, non-metallic, natural and non-natural materials including, but not limited to: aluminium alloys, steel alloys, zinc alloys, titanium alloys, copper alloys, magnesium alloys, nickel alloys, brass alloys, carpenter, gold, silver, platinum, hastelloy, haynes alloy, inconel, molybden alloy, palladium, bronze, tantalum, monel, tungsten, borron, beryllium, zintec, matrix composites, thermoplastics, thermosets, plastics, foams, wood, rubber, paper, ceramics, leather, balsa, cedar.

The laminate as their integral components may include structures based on a variety of metallic, non -metallic, natural and non-natural materials such as, but not limited to: aluminium alloys, steel alloys, zinc alloys, titanium alloys, copper alloys, magnesium alloys, nickel alloys, brass alloys, carpenter, gold, silver, platinum, hastelloy, haynes alloy, inconel, molybden alloy, palladium, bronze, tantalum, monel,

tungsten, borron, beryllium, zintec, matrix composites, thermoplastics, thermosets, plastics, foams, wood, rubber, paper, ceramics, leather, balsa, cedar, liquids and gases (vacuum) as a single components or compositions.

Nanostructures may be formed as described above, with substitution of expensive materials such as boron, with materials mentioned, to reduce current high prices and make them widely available to industry, but they are not limited only to these components.

As the second stage of fabricating parts/structures with the laminates, it is possible to use most of technologies used in metal and plastics forming processes such as, but not limited to: moulding and stamping, as well as technologies used in cold deformation forming processes such as, but not limited to: blanking, punching, flanging, embossing, bending and drawing.

Primary and secondary structures designed, created and manufactured on the basis of the laminate material design philosophy , can be used in the:

- aviation industry (civil and military),
- space industry (civil and military),
- train and rail industry (civil and military),
- maritime industry (civil and military),
- automotive industry (civil and military),
- all sorts of building industry (civil and military),
- protective industry/ballistic (civil and military),
- construction industry, decoration, machinery, furniture and municipal engineering, road-side safety barriers, and similar,
- multiple general applications,
- materials developed through nanotechnology.

EXAMPLES

For example, measured and calculated average properties of laminate sample made from two outer layers of E-Glass quadriaxial woven fibre 1200 gr/m2, one

PCT/AU2004/001004
Received 17 June 2005

internal/dissipation element: Aluminium Ornamesh Type R, and Vinylester resin DERAKANE 411-350, are:

- Tensile Strength $\sigma > 1000$ MPa,
- Density $\rho = 2247$ kg / m3,
- Peak Impact Force F = 184.3 kN (without penetration),
- Impact Energy Absorbed EA = 3985 J (without penetration),
- Deflection 41 mm,
- Young's modulus of elasticity E = 33 GPa,
- Poison's ratio $\nu = 0.33$.

Density of some High Strength, Impact Resistant, Elastic Composite Laminate design solutions may be significantly reduced to 1600 kg / m3.

Table 1. Comparison of selected mechanical properties of materials now in use in the automotive and aviation industries with some of the laminates of the invention.

Materials	Thickness [mm]	Specific Weight [kg/m3]	Weight per 1m2 [kg/m2]	Absorbed Impact Energy [J]	Specific Absorbed Impact Energy/Weight [J/kg]	Deformation [mm]	Peak Force [kN]	Tensile Strength [MPa]
Aluminium	1.5	2750	4.13	0	0	perforated	-	485
Steel	0.8	7850	6.28	0	0	perforated	-	655
Steel	1.5	7850	11.78	4272	1453	69	133.4	655
Honey.Comp.	4.3	1220	5.25	-	-	perforated	-	-
Glare-5	2.0	2590	5.18	150	-	perforated	10.3	-
NHSIRECL 1	2.9	2247	6.51	3985	1510	41	184.3	>1000
NHSIRECL 2	5.0	1934	9.67	3778	1108	13	153.9	>1000
NHSIRECL 6	15.2	1304	19.82	3919	688	29	176.0	>1000
DYN 1	-	-	-	3727	-	perforated	91.7	-
DYN 5	-	-	-	4100	-	perforated	69.9	-

Legend:

- Data for Glare-5, "Application of Fibre-Metal Laminates", Polymer Composites, August 2000, [Absorbed Impact Energy (maximum) before Perforation],
- Data for DYN 1, and DYN 5 (Structures based on Kevlar reinforcements), form "Impact Testing in Formula One", A. N. Mellor, (Absorbed Impact Energy within displacement of 100 mm) Transport Research Laboratory, Crowthorne, England, ("ICRASH 2002" International Conference, February 2002, Melbourne),
- NHSIRECL – Composite Laminates of the invention.

PCT/AU2004/001004
Received 17 June 2005

Samples (Aluminium, Steel and NHSIRECL) were rigorously tested on a controlled drop weight impact tower with an impactor made from solid steel, weighing 45 kg. The impactor head was formed as sphere of diameter 200 mm. Sample dimensions were 500 x 500 mm. The speed of the impactor at the moment of impact was 55 km/h.

The comparison between Steel sample thickness 1.5 mm and sample NHSIRECL 1 (Table 1), shows that the level of impact energy absorbed by NHSIRECL 1 is 93% of the impact energy absorbed by the Steel sample with 40% lower deflection. At the same time, the weight reduction between NHSIRECL 1 and Steel 1.5 mm is more than 100%.

In comparison with Steel 1.5 mm sample, NHSIRECL 2 shows high level of plastic/elastic deformation, superior deflection reduction with significant weight reduction. Deflection of NHSIRECL 2 is only 20% of deflection recorded by the Steel sample, with 88% of impact energy absorbed of these absorbed by the Steel sample.

Use of the laminates of the invention delivers highly controlled and predictable behaviour under load, accompanied by:

- manufacturing costs can be significantly minimized since known and established manufacturing processes are used;
- manufacturing time can be significantly minimized since known and established manufacturing processes are used and manufacturing simplicity;
- materials costs can be significantly minimized since already available, cost – effective materials are used,
- materials costs can be significantly minimized since reduced number of applied reinforcement plies
- significant finished-product weight reduction;
- demonstrated increases in mechanical properties through its substitution for heavier (steel and aluminium) and more expensive metals;
- expected improved fatigue resistance;
- low maintenance and repair costs;

PCT/AU2004/001004
Received 17 June 2005

- the possibility of innovative cost-saving solutions to design problems now limited by the necessity to use conventional heavier metal sheeting;
- the possibility to manufacture complex sections with reduced number of primary parts in an assembly.

The desirable properties of the laminates (high strength, high impact resistance, elasticity/plasticity) give their user a unique opportunity to create structures exhibiting easily replicated, tightly controlled behaviour under a wide range of loads, especially under extreme impact loading.

The physical properties of the laminates could be widely varied and precisely tailored to the needs of the particular end use application by combining various sorts of materials in large number of permutations for creating new structures.

The result of all above mentioned is an opportunity of global implications for the application and further development of high-tech, high-impact strength, elastic/plastic, cost-effective, lightweight products and components for everyday use in manufacturing, transport, packaging and variety of civil and military industry in general.

Although particular preferred embodiments of the invention have been disclosed in detail for illustrative purposes, it will be recognised that variations of permutations and modifications of the disclosed invention, including the use of various materials/components in creating the laminate lie within the scope of the present invention.

PCT/AU2004/001004
Received 17 June 2005

The claims:

1. A high strength impact resistant, elastic, composite laminate including:
at least two inner fibre plies between the outer layers, and
at least one dissipating element between the inner plies, wherein said at least one dissipating element dissipates and redirects a load applied to the laminate to tensile loading of at least one of said inner plies directed along its longitudinal axis.

2. The laminate according to Claim 1, wherein both inner plies are mainly tensilely loaded, said tensile loading being directed along the respective longitudinal axes of said inner plies.

3. The laminate according to Claim 1 or 2, wherein the at least one dissipating element substantially induces an equilibrium between said load and said tensile loading and a component of said load is redirected along a main fibre axis of said at least one inner ply.

4. The laminate according to any preceding Claim, wherein the at least one dissipating element is made from, but are not limited to, one or more of the following materials: metal, metal alloys, thermoplastics, plastics, polymers, foams, metallic foams, wood and rubber.

5. The laminate according to Claim 4, wherein said metal alloys include, but are not limited to: aluminium alloys, steel alloys, zinc alloys, titanium alloys, copper alloys, magnesium alloys, nickel alloys and alloy matrix composites.

6. The laminate according to any preceding Claim, wherein the at least one dissipating element is in the form of, but not limited to: sheet, corrugated sheet, mesh, tubular shape, spherical shape, foam or other foam-like structure.

7. The laminate according to Claim 4 or 5, wherein the at least one dissipating

element is in the form of an expanded or rigidised metal.

8. The laminate according to any preceding Claim, wherein the at least one dissipating element has, but is not limited to: cross-ply, unidirectional, symmetric, balanced or quasi-isotropic orientation in the laminate.

9. The laminate according to any preceding Claim, wherein there is a plurality of dissipating elements.

10. The laminate according to claim 9, wherein a ply is formed by two or more of said dissipating elements.

11. The laminate according to claim 10, wherein said ply has, but is not limited to: cross-ply, unidirectional, symmetric, balanced or quasi-isotropic orientation in the laminate.

12. The laminate according to any preceding Claim, wherein one or both of said inner plies are reinforcement plies.

13. The laminate according to Claim 12, wherein one or both of said inner plies are made from single reinforcement fibre or hybrid reinforcement fibre.

14. The laminate according to Claim 13, wherein said single reinforcement fibre is made from one of, but not limited to: glass, aramid and carbon/graphite fibres.

15. The laminate according to Claim 13, wherein said hybrid reinforcement fibre is made from two or more of, but not limited to: glass, aramid and carbon/graphite fibres.

16. The laminate according to any one of claims 12 to 15, wherein said reinforcement fibres are formed as, but not limited to: unidirectional woven fibres,

PCT/AU2004/001004
Received 17 June 2005

biaxial woven fibres, triaxial woven fibres, quadriaxial woven fibres, double-bias woven fibres, plain woven fibres or woven rovings.

17. The laminate according to any one of claims 12 to 16, wherein one or both of said inner plies have, but not limited to: cross-ply, unidirectional, symmetric, balanced, quasi-isotropic or hybrid orientation in the laminate.

18. The laminate according to any one of Claims 12 to 17, wherein there is a plurality of inner plies.

19. The laminate of any preceding Claim, wherein the polymer matrix is made from one or, but not limited to more thermosetting or thermoplastic matrix groups.

20. The laminate according to Claim 19, wherein said polymer matrix is made from one or more of the following, but not limited to: vinyl ester resin, epoxy resin, phenolic resin, polypropylene, nylon, fire retardant resin and corrosion resistant resin.

21. The laminate according to Claim 19 or 20, wherein said polymer matrix includes one or more adhesives.

22. The laminate according to any one of Claims 19 to 21, wherein said polymer matrix includes one or more coatings.

23. The laminate according to any one of Claims 19 to 22, wherein said polymer matrix includes one or more pigments.

24. The laminate according to any one of the preceding claims, wherein the laminate includes a pair of outer layers and a polymer matrix between each of the plies and the outer layers.

25. The laminate according to claim 24, wherein said outer layers are made from

one or more of the following materials, but not limited to: metal, metal alloys, wood, plastics, rubber, paper, thermoplastics, polymers, foams and rubber.

26. The laminate according to Claim 25, wherein said metal alloys include, but are not limited to: aluminium alloys, steel alloys, zinc alloys, titanium alloys, copper alloys, magnesium alloys, nickel alloys, and alloy matrix composites.

27. The laminate according to any preceding Claim, further including at least one additional layer having, but not limited to: honeycomb, hybrid sandwich or foam structure.

28. The laminate according to Claim 27, wherein said additional layer is made from one or more of, but not limited to, the following materials: metal, wood, rubber, plastics, polymers, paper and thermoplastics.

29. The laminate according to any preceding Claim, wherein said laminate absorbs impact energy from but not limited to 3770 to about 4000 J.

30. The laminate according to any preceding Claim, wherein said laminate absorbs and redirects forces from, but not limited 150 to about 190 kN.

31. The laminate according to any preceding Claim, wherein said laminate has a density range from, but not limited to 1300 to about 2250 $kg/m^{3.}$

32. The laminate according to any preceding Claim, wherein said inner plies are made from, but not limited to, E-glass quadriaxial woven fibre, said polymer matrix is substantially made from vinyl ester resin and said at least one dissipating element is an aluminium mesh.

33. A nanostructure including:

at least two inner fibre plies between the outer layers, and

at least one dissipating element between the inner plies, wherein said at least one dissipating element dissipates and redirects a load applied to the laminate to tensile loading of at least one of said inner plies directed along its longitudinal axis.

34. The nanostructure according to Claim 33, wherein both inner plies are tensilely loaded, said tensile loading being directed along the respective longitudinal axes of said inner plies.

35. The nanostructure according to Claim 33 or 34, wherein the at least one dissipating element substantially includes an equilibrium between said load and said tensile loading and a component of said load is redirected along a main fibre axis of said at least one inner ply.

36. The nanostructure according to any one of Claims 33 to 35, wherein the at least one dissipating element is made from one or more of the following materials, but not limited to: metal, metal alloys, thermoplastics, plastics, polymers, foams, metallic foams, wood and rubber.

37. The nanostructure according to Claim 36, wherein said metal alloys include, but are not limited to: aluminium alloys, steel alloys, zinc alloys, titanium alloys, copper alloys, magnesium alloys, nickel alloys and alloy matrix composites.

38. The nanostructure according to one of Claims 33 to 37, wherein the at least one dissipating element is in the form of a, but not limited to: sheet, corrugated sheet, mesh, tubular shape, spherical shape, foam or foam-like structure.

39. The nanostructure according to Claim 37 or 38, wherein the at least one dissipating element is in the form, but not limited to expanded or rigidised metal.

PCT/AU2004/001004
Received 17 June 2005

40. The nanostructure according to any one of Claims 33 to 39, wherein the at least one dissipating element has, but is not limited to: a cross-ply, unidirectional, symmetric, balanced or quasi-isotropic orientation in the nanostructure.

41. The nanostructure according to any one of Claims 33 to 40, wherein there is a plurality of dissipating elements.

42. The nanostructure according to any one of Claims 33 to 41, wherein one or both of said inner plies are reinforcement plies.

43. The nanostructure according to Claim 42, wherein one or both of said inner plies are made from single reinforcement fibre or hybrid reinforcement fibre.

44. The nanostructure according to Claim 43, wherein said single reinforcement fibre is made from one of , but is not limited to: glass, aramid and carbon/graphite fibre.

45. The nanostructure according to Claim 42 or 43, wherein said hybrid reinforcement fibre is made from two or more of, but not limited to: glass, aramid and carbon/graphite fibres.

46. The nanostructure according any one of Claims 42 to 45, wherein said reinforcement fibres are formed as, but not limited to: unidirectional woven fibres, biaxial woven fibres, triaxial woven fibres, quadriaxial woven fibres, double-bias woven fibres, plain woven fibres or woven rovings.

47. The nanostructure according to any one of claims 33 to 46, wherein one or both of said inner plies have, but are not limited to: a cross-ply, unidirectional, symmetric, balanced, quasi-isotropic or hybrid orientation in the nanostructure.

48. The nanostructure of any one of Claims 33 to 47, wherein the polymer matrix

is made from one or more thermosetting and thermoplastic matrix groups.

49. The nanostructure according to Claim 48, wherein said polymer matrix is made from one or more of the following, but not limited to: vinyl ester resin, epoxy resin, phenolic resin, polypropylene, nylon, fire retardant resin and corrosion resistant resin.

50. The nanostructure according to Claim 48 or 49, wherein said polymer matrix includes one or more adhesives.

51. The nanostructure according to any one of Claims 48 to 50, wherein said polymer matrix includes one or more coatings.

52. The nanostructure according to any one of Claims 48 to 51, wherein said polymer matrix includes one or more pigments.

53. The nanostructure according to any one of claims 33 to 52, wherein the laminate includes a pair of outer layers and a polymer matrix between each of the plies and the outer layers.

54. The nanostructure according to claim 53, wherein said outer layers are made from one or more of the following materials, but are not limited to: metal, metal alloys, wood, plastics, rubber, paper, thermoplastics, polymers, foams and rubber.

55. The nanostructure according to Claim 54, wherein said metal alloys include, but are not limited to: aluminium alloys, steel alloys, zinc alloys, titanium alloys, copper alloys, magnesium alloys, nickel alloys, and alloy matrix composites.

56. The nanostructure according to any one of Claims 33 to 55, further including at least one additional layer having, but not limited to: a honeycomb, hybrid sandwich or foam structure.

PCT/AU2004/001004
Received 17 June 2005

57. The nanostructure according to Claim 56, wherein said additional layer is made from one or more of the following materials, but not limited to: metal, wood, rubber, plastics, polymers, paper and thermoplastics.

58. The nanostructure according to any one of Claims 33 to 57, wherein said outer layers are made of, but are not limited to: E-glass quadriaxial woven fibre, said polymer matrix is substantially made from vinyl ester resin and said at least one dissipating element is made from aluminium mesh .

59. A laminate substantially as described with reference to the drawings and/or Examples.

60. A nanostructure substantially as described with reference to the drawings and/or Examples.

PCT/AU2004/001004
Received 17 June 2005

ABSTRACT

A damage resistant High Strength, Impact Resistant, Elastic Composite Laminate primary (singular) structure with optionally having first (4) and second (4) outer face layers, having first (2) and second (2) inner reinforced plies being located between the first and second outer layers, and (1) a dissipating element located between the first and second reinforced plies, wherein the dissipating element is adapted to dissipate and redirect, randomly directed active loading applied to at least one of the two outer surface, to tensile loading being directed along the respective longitudinal axis of the inner reinforced ply; and a matrix (3) between (2) and (4).